SOILutions

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SOIL PH AND PLANT NUTRIENTS WHAT'S THE CONNECTION?

Ross H. McKenzie, Supervisor, Crop Nutrition

I am frequently asked, "What effect does soil pH have on availability of nutrients in the soil?" There is no simple answer to this question, since the effects of pH are complex and vary with different nutrients, but some broad generalizations are useful to keep in mind when making nutrient management decisions.

The first order of business is a quick review of pH and the associated terminology. Using a strict chemical definition, pH is the negative log of H^+ activity in an aqueous solution. The point to remember from the chemical definition is that pH values are reported on a negative log scale. Therefore a 1 unit change in the pH value signifies a 10 fold change in the actual activity of H^+ and that the activity increases as the pH value decreases.

As agronomists, we generally use soil pH as measured in a 2:1 water to soil mixture as an index of a soil's acidity or alkalinity. In a soil test report pH is often reported with descriptive modifier as shown in the table on page 2.

Cont. Page 2

LOW SOIL TEST N LEVELS IN STUBBLE FIELDS

Len Kryzanowski, Crop Nutrition Agronomist

A summary of fall 1990 soil samples indicates low levels of soil test N in stubble fields across the province. Soil test N under annual grain stubble is consistent with long term averages, but appear to be significantly lower than in 1989 (see table page 3). Approximately 80% of soil samples from dryland grain stubble had less than 25 lb N/ac in the 0-6" depth. This trend was consistent across all soil test areas. Nitrogen levels under irrigated grain stubble were highly variable. Average soil test N levels under fallow fields were higher than the long term average with 65% of samples showing greater than 35 lb N/ac in the 0-6" depth.

For producers considering reduction of fertilizer inputs, the implication is that N reserves may not be adequate and higher rates of N fertilizer will be required to maintain crop production levels. This summary only indicates general trends and should be used with caution. For reliable estimates of available N, producers should have their fields tested . Soil testing is an effective tool for measuring

Cont. Page 3

THIS ISSUE:

Alberta Agriculture

Soil pH and Interpretation

	5.5	6.0	6.5	7.0	7.5	8.0
Strongly Acid	Medium Acid	Slightly Acid	Neutral	Neutral	Mildly Alkaline	Moderately Alkaline
		Best Range for Most Crops				

pH Continued

Let's start our examination of pH and nutrients with nitrogen (N). Plants can take up N in the ammonium (NH_4^+) or nitrate (NO_3^-) form. At pHs near neutral (pH 7), the microbial conversion of NH_4^+ to nitrate (nitrification) is rapid and crops generally take up nitrate. In acid soils (pH < 6), nitrification is slow and plants with the ability to take up NH_4^+ may have an advantage.

Soil pH also plays an important role in volatilization losses. Ammonium in the soil solution exists in equilibrium with ammonia gas (NH_3). The equilibrium is strongly pH dependent. (You have no doubt noticed that the difference between NH_3 and NH_4^+ is a H^+.) For example, if NH_4^+ were applied to a soil at pH 7, the equilibrium condition would be 99% NH_4^+ and 1% NH_3. At pH 8 approximately 10% would exist as NH_3.

This means that a fertilizer like urea (46-0-0) is generally subject to higher losses at higher pH. But it does not mean that losses at pH 7 will be 1% or less. The equilibrium is dynamic. As soon as a molecule of NH_3 escapes the soil, a molecule of NH_4^+ converts to NH_3 to maintain the equilibrium. There are other factors such as soil moisture, temperature, texture, and cation exchange capacity that can effect volatilization. So pH is not the whole story. The important point to remember is that under conditions of low soil moisture or poor incorporation, volatilization loss can be considerable even at pH values as low as 5.5.

Soil pH is also an important factor in the N nutrition of legumes. The survival and activity of *Rhizobium*, the bacteria responsible for N fixation in association with legumes, declines as soil acidity increases. This is of particular concern when attempting to grow alfalfa on soils with pH below 6.

The form and availability of soil phosphorus (P) is also highly pH dependent. Plants take up soluble P from the soil solution, but this pool tends to be extremely low, often less than 1 lb/ac. The limited solubility of P relates to its tendancy to form a wide range of stable minerals in soil. Under alkaline soil conditions, P fertilizers such as mono-ammonium phosphate (11-55-0) generally form more stable (less soluble) minerals through reactions with calcium (Ca). Contrary to popular belief, the P in these Ca-P minerals will still contribute to crop P requirements. As plants remove P from the soil solution the more soluble of the Ca-P minerals dissolve and solution P levels are replenished. Our greenhouse and field research has shown that a portion of the fertilizer P tied up this year in Ca-P minerals will be available to crops in subsequent years.

The fate of added P in acidic soils is somewhat different as precipitation reactions occur with aluminum (Al) and iron (Fe). The tie up of P in Al-P and Fe-P minerals under acidic conditions tends to be more permanent than in Ca-P minerals.

Fixation of potassium (K), entrapment at specific sites between clay layers, tends to be lower under acid conditions. This is thought to be due to the presence of soluble aluminum which occupies the binding sites. One would think that raising the pH through liming would increase fixation and reduce K availability. This is not the case, at least in the short-term. Liming increases K availability likely through displacement of exchangeable K by Ca.

Sulfate (SO_4^{2-}) sulfur, the plant available form of S, is little affected by soil pH.

The availability of the micronutrients manganese (Mn), iron (Fe), copper (Cu), zinc (Zn), and boron (B) tends to decrease as soil pH increases. The exact mechanisms responsible for reducing availability differ for each nutrient, but can include formation of low solubility compounds, greater retention by soil colloids (clays and organic matter), and conversion of soluble forms to ions that plants cannot absorb. Molybdenum (Mo) behaves counter to the trend described above. Plant availability is lower under acid conditions.

So there you have it! Soil pH does play a role in nutrient availability. Should you be concerned? More aware than concerned. Keep the pH factor in mind when planning nutrient management programs. Also keep a historical record of soil pH in your fields. Soils tend to acidify over time particularly when large application of NH_4^+ based fertilizers are used or there is a high proportion of legumes in the rotation. On the other hand, seepage of alkaline salts can raise the pH above the optimum range. So a soil with an optimum pH today may be too acid or alkaline a decade from now.*

Average Fall Soil Test Nitrate-Nitrogen (lb/ac) 0-6"

Soil Zone		1990	1989	1988	1962-90
Brown	stubble	26	55	16	18
	fallow	NA	NA	NA	32
Dark Brown	stubble	16	24	17	17
	fallow	43	48	32	33
Thin Black	stubble	17	25	23	19
	fallow	NA	NA	52	41
Black	stubble	15	31	24	19
	fallow	64	57	59	46
Gray NW	stubble	22	32	21	17
	fallow	66	50	50	41
Gray NE	stubble	NA	NA	NA	16
	fallow	NA	NA	NA	40
Peace River Region	stubble	14	14	12	22
	fallow	36	21	48	46

Low Soil Test Levels Continued

available soil nutrients and determining fertilizer requirements.

Spring soil sampling is no different than fall sampling. The same rules apply, but it must be stressed that the soil test results and subsequent recommendations are only as good as the soil sample collected. Poor sampling technique will produce unreliable results and questionable recommendations. The main restraint on spring soil testing is the time needed for proper soil sampling plus the time necessary for laboratory analysis and return of recommendations. Most producers cannot afford the time to sample all fields, but should consider sampling one or two fields if they are unsure of their fertilizer plans.

Producers should collect 15 to 20 cores from each field taking care to avoid any small unusual areas. Large areas of the field with different management histories, for example manure applications, should be sampled separately.

Proper handling of the soil once the sample has been collected is critical if you want reliable results. The best procedure is to spread the sample out immediately on a clean sheet of plastic and when the sample is air dry send it to the laboratory when air dry. Alternatively, the sample can be kept refrigerated for up to 3 days prior to delivery to the lab. Research results from the Saskatchewan Soil Testing Laboratory indicate that freezing soil samples may cause significant changes in the N levels and should be avoided. If you have doubts about how to store and ship samples contact your lab prior to sampling.

Take the time to fill out the information sheet when submitting the sample. Previous crop, crop to be grown, legal location, previous fertilizer or manure management, and special management problems are essential information for formulating a fertilizer recommendation.

Send your samples to a reputable lab that bases their recommendations on knowledge derived from the region in which you farm. For routine fertility analysis, Alberta's private commercial soil testing labs provide quick turn around time at competitive prices. Soils Branch staff are always ready to help with soil test interpretation regardless of where the samples were analyzed. For further information regarding soil testing, contact your Alberta Agriculture district office, fertilizer dealer or soil testing laboratory.✔

SCIENCE AND AGRICULTURE

The Missing Link

Robert F. Grant, Dept of Soil Science, U of A

Scientists have been studying agricultural problems for decades. For example, some scientists have been studying how energy is transferred between crops and the atmosphere, and they have developed a lot of of expensive instruments by which to measure energy transfer. This may or may not seem important to crop production, except through this energy transfer, crops exchange water from the soil for carbon dioxide from the air, and thus they transpire and grow. Anyone from an irrigation district knows how important it is to know how much transpiration is taking place. However, when we want to know how much water is being removed from the soil, we do not consider the processes by which that removal is controlled. Rather, we rely on estimates from evaporation pans and crop coefficients that may or may indicate what is happening in a particular crop. All that expensive research into energy transfer is not used.

Similarly, some scientists have been studying how roots take up nutrients from the soil solution. They have used hydroponic cultures under controlled nutrient conditions to clarify fundamental principles controlling the movement and uptake of nutrients by plants. However, when we wish to know how much nutrient we need to have in the soil to meet crop requirements, we rely on estimates from field trials that may or may not indicate what is happening in a particular soil and crop. Again the fundamental research is not used.

The reason that this fundamental research is not used in the solving of practical production problems is that it involves the detailed study of one particular process, such as energy exchange or nutrient uptake. However, resource managers must consider an entire ecosystem, consisting of a multitude of different, but interacting, processes. There is a growing realization in the scientific community that ways must be found to clarify not just the processes, but the way these problems interact to control ecosystem behaviour. One way in which this is attempted is through mathematical modelling, because the findings from these different areas of research can be expressed in a common language - mathematics.

Because there are a multitude of processes, a mathematical model of an ecosystem will be very large. The model being developed and tested at the University of Alberta runs on a supercomputer in the U.S. However, this does not mean the model is difficult to understand or use. With the high-speed communications networks of today, it is just as easy to use a supercomputer (if you have an account) as it is to use a personal computer. In fact, high school students now use supercomputers for their science projects. However, supercomputers allow researchers to examine system behaviour in a way not possible with smaller computers. One question being asked of the ecosystem model is what will happen to crop production in Alberta if the global climate changes? Other questions relating to irrigation or fertility management may also be asked of the model.

Any new technology, such as a mathematical model, needs to be developed and tested very rigorously before it is used in ecosystem management. For example, a new herbicide takes years to develop in a laboratory. Once a promising herbicide is developed, its behavior must be tested over several years in field trials to determine how it should and should not be used. Only after its behavior has been monitored over several years is it released for use. The ecosystem model at the University of Alberta is going through a similar process. It is being developed and tested in our laboratory here, using specialized experimental data reported from other universities and research institutes around the world. Its field performance will soon be tested against field data collected from detailed field trials in Alberta, such as the ecosystem plots at Breton and Ellerslie, to see how it reproduces in mathematical form such phenomena as crop growth, water stress, organic matter changes, nutrient uptake and nutrient loss. At a later stage of development, it may be used to study resource management issues at production sites, such as fertilizer and water requirements.

Modeling can provide us with important insights into how the ecosystem behaves under different crop, soil, climate and management regimes. It should be emphasized, however, that this technology is not a substitute for good site data such as that from soil sampling. Rather, it allows more detailed site data to be considered when making management decisions. It is therefore important that good site data continue to be recorded from regular sampling programs.❋

CONSIDER SEED ROW WIDTH WHEN SEED PLACING NITROGEN

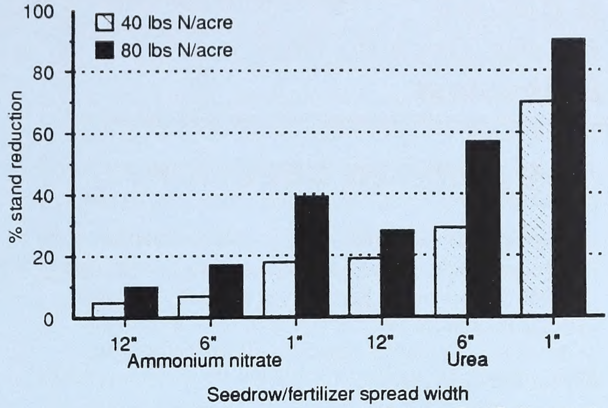
Doug Beever, Sherritt Agronomist

Seed placing nitrogen is one of the most cost effective means of applying your fertilizer. Nitrogen fertilizers can, however, reduce emergence and yields when application rates are high and the amount of fertilizer adjacent to the seed becomes excessive.

Wider Seed Rows Reduce Stand Damage

The development of seeders which spread the fertilizer and seed over a wide area has led farmers to ask if additional fertilizer can be seed placed in wider seed rows. To answer this question researchers at the University of North Dakota conducted an experiment using varying amounts of urea and ammonium nitrate applied in seed rows of 12, 6 and 1 inch widths. The 12 inch width covered 100% of the potential seedbed, while the 6 inch and 1 inch row widths covered 50% and 8% of the potential seedbed, respectively.
The results of the experiment, illustrated here, shows less seed and/or seedling damage (stand reduction) at wider seed row widths. The wider row width allows the fertilizer and seed to be spread over a greater area. This reduces the concentration of fertilizer immediately adjacent to the seed and lowers the potential for stand damage.

Percent cereal stand reduction as a result of seedrow width, nitrogen source and nitrogen rate



Source: E.J. Deibert et al.

Application Rates Need Research

The above study tells us that more fertilizer nitrogen can be seed placed when wider rows are used, however, it does not tell us how much more. The information required to make these recommendations has not been developed for all seed row widths and spacing situations. As a result, very few recommendations have been made other than for specific situations and row widths (ie. Alberta Agriculture).

Other Factors to Consider

It is important to note that safe seed placement rates vary not only with method of placement, but with fertilizer type, crop type and soil condition. Proper consideration of these factors and your own on-farm testing will allow you to determine a safe seed placement rate for your farming situation.

Maximum N Rates for Placement for Seed (Source: Alberta Agriculture)

			*Double disc or narrow hoe drill		**Pneumatic Seeder 50% spread	
			Source of Nitrogen		Source of Nitrogen	
Crops	Soil Texture	Seedbed Moisture	Urea	Ammonium Nitrate	Urea	Ammonium Nitrate
			lb/ac of Nitrogen (N)		lb/ac of Nitrogen (N)	
Wheat, Oats and Barley	Medium, Fine	Good	30	45	45	65
		Poor	20	30	30	45
	Light (Sandy Loam)	Good	20	30	35	55
		Poor	15	20	25	35
Small seed crops (canola, mustard, flax & cereals underseeded with a legume that is placed in the seed row)	All soil textures	All moisture	10	10	20	35

*Conventional seeder - double disc or narrow hoe opener (1-2 inch spread of seed and fertilizer)
**Pneumatic seeder - cultivator with sweeps at 12 inch spacing giving 50% spread of seed and fertilizer.

PEATNIK
A Column for the Organic Soil Enthusiast

Rick Sherstabetoff
Organic Soils Specialist

THE BURNING QUESTION?

Producers frustrated by poor crop production on peatlands often contemplate burning the surface layer of peat to improve crop yields. Burning can result in a dramatic increase in productivity, but you need to consider some of the adverse as well as beneficial effects before you run out and flick your bic.

The beneficial effects of burning mainly accrue from the release of nutrients immobilized in the peat and from a liming effect from the ash. A good burn will convert the surface layer to an alkaline ash that can then be mixed in with the underlying acidic peat to form a nutrient rich surface layer with a near neutral pH. Burning is particularly beneficial when the surface layer is composed of raw sphagnum or is sufficiently acidic to retard growth.

Measuring the short-term benefits of burning is simple: you burn, you mix, you seed, you harvest, you sell, you examine your profit margin. If it has increased, burning worked. Gauging the risks associated with burning is considerably more difficult.

Burning can have some detrimental effects at the community level. Smoke produced during burning contributes to air pollution. It also reduces visibility and increases the potential for accidents on roads near the burn. Of course, this doesn't effect your profit margin, unless you are the knucklehead that puts the truck in the ditch.

What if productivity declines following the burn? This is not a management practice that can be easily undone. The table below show some of the physical and chemical changes that accompany a peat burn. The characteristics of a productive mineral soil have been included in the table as a reference.

Notice that by itself the peat ash is not a good medium for plant growth. It's alkaline and saline, doesn't hold water, tends to erode, and is extremely low in nitrogen. It has to be mixed with unburned peat or mineral soil before the beneficial effects can be realized.

What if the ash layer is to deep to be effectively mixed? What if the burn is uneven and creates pockets that pond water? What if the whole mess blows away next spring? Consider the potential risks along with the potential benefits before you burn.

Another point to consider is the value of the lost nitrogen. Burning converts most of the soil N from organic to mineral forms that escape from the soil as part of the combustion gases. The ash tends to be enriched in readily plant available forms of N, so in the short term (1-3 years) burning improves N nutrition. However, in the long term burning severely reduces the N supplying power of the soil.

Research data suggests that the top six inches of a peat soil will mineralize from 30-200 lbs N/acre/year. Let's assume that in the long term, burning a typical peat reduces the crop's supply of N by 40 lbs/acre/year. If it costs $0.25/lb to replace the lost N with fertilizer N, the annual value of the lost N would be $10/acre/year. That's $10 you have to dig out of your pocket and risk loosing in order to produce a crop.

The above analysis is simplistic but it adequately illustrates the point. The benefits of burning must outweigh the costs over the long term in order to make it pay. So don't let the siren song of short term productivity gains lead you to long term financial pain.

SoilProperty	Ash from Peat Burn	Peat	Mineral Soil
Total N Content (%)	0-0.2	1.0-2.5	0.5-1.0
Soil pH*	>9.5	5.0-6.0	6.0-7.0
Electrical Conductivity (mS/cm)**	>7	<1	<2
Field Capacity Moisture (%)	<10	>400	30-50
Erosion Risk	severe	moderate to high	low to moderate

*Ideal pH range 6.0-8.0

** Growth impaired for most crops at EC values greater than 4.

SOIL SEARCHING

MISSING THE MARK

A Few Definitions

Bench mark. A surveyor's mark made on some stationary object of previously determined position and elevation, and used as a reference point in tidal observations and surveys.

Bench mark site. 1. A parcel of agricultural land carefully selected such that its soil, climate, and past management make it representative of an agroclimatic zone or region. 2. A place where integrated, interdisplinary, interagency agronomic research is carried out on a continuing basis. 3. An idea to which lip service should be continually given, but which should never be taken seriously.

I first heard the term bench mark site bantered about over a decade ago. It was part of a larger concept that would see the development of farming systems that made best use of the climate, soil, and infrastructure resources in the different regions of the province. These sites would not only be used to fine tune and incorporate new technology into existing production systems in an orderly and scientific manner, but they would also provide a level playing field on which to test radical new concepts in crop production.

The visionaries of a decade ago saw the need for an infrastructure that would bring together the human and capital resources within the province and spark the synergism necessary to make Alberta a center of excellence in the field of agronomic research. They saw the agroecosystem approach incorporating bench mark sites as a powerful unifying tool that would weld fundamental to applied research to extension and technology transfer.

The heart of each bench mark site would be a long term core program aimed at producing sustainable agricultural systems for an agroecological resource area (AERA for short). It would include aspects of soil management, crop protection, variety improvement, and agrometerology. Fundamental research at AERA sites would elucidate underlying principles in agroecosytem behavior, while applied research would examine ways to manipulate this behavior into sustainable farming systems.

A comprehensive ecological data base would be compiled for each AERA site. As research at these sites continued the accumulated body of knowledge and well developed infrastructure would attract research funds from a wider variety of research agencies. Industry, commodity, applied and fundamental research groups would all want to carry out short-term research at AERA sites. Why? Because new data generated would rest on a firm foundation of preexistent site knowledge and thus be of greater value. In addition to providing knowledge on how to produce crops, monitoring site parameters would allow quantitative assessment of the impact of agronomic practices on the resource base.

When coupled to the emerging generation of agroecosystem models (see Missing Link article), the AERA data base would provide both fundamental and applied researchers with a powerful new research tool. The ability to simulate experimental treatments and estimate the outcomes before carrying out expensive field trials. By using this approach, researcher could direct their funds into the most promising areas of research.

This concept of increasing attraction is not mere supposition on our part, but firmly based in precedent. Dr. Marv Nyborg of the U of A started a long term experiment examining straw-tillage management systems in the early 80's. In the early going, funding was never adequate and Marv had to beg, borrow, and steal to keep the plots going. Several generations of grad students, research associates, and field technicians were coerced into managing the plots. Often helping Marv evenings and weekends to insure the work got done. Today the straw-tillage plots cannot accomodate all the requests Marv receives for their use in other researchers projects.

Would've, Should've, Could've

But we didn't establish bench mark sites during the 80's. Why? In large part because the necessary long term infra structure funding did not gain political support and was thus not available. The lack of political support can be attributed to a variety of reasons. Tax dollars were and continue to be thinly stretched and long term commitments reduce spending flexibility. During the 80's, agriculture was perceived as an industry in decline and farmers as a burden on the public purse and a threat to the environment. Consequently, it is no surprise that politicians wanted to channel funds into what

Cont. Page 8

were perceived as more promising opportunities. Even when times are good, agricultural research gains political points with a fairly narrow sector of society, mainly rural dwellers, whereas more glamorous research areas such as medicine have a universal appeal.

It is easy to drop the blame for missed opportunity on the head of the body politic, but such blame would be largely misplaced. The main reason why the vision of an integrated research system has not been realized lies within ourselves. Millions of dollars were spent on agricultural research in the province during the last decade and the agriculture sector for the most part had control over how those dollars were spent. We decided to spend them in large part on solutions to narrowly defined problems involving single disciplines rather than on broadly based interdisciplinary programs.

Those of us who championed a unified approach, whether in agronomy or some other field, generally did so within the context of our own organization holding the purse strings and calling the shots. Despite an abundance of data showing that our research yields a handsome return, we failed to convince the politicians, the public at large, and our peers of the merits of investing in agriculture. When push came to shove, most of us scrambled to curry favor for our personal research agendas and were ably aided and abetted in this pursuit by organizational structures and mind sets that made it much easier to build walls than bridges.

In raising venture capital for a business, convincing investors that you know your customers and can deliver the right products at a price that insures a good return is of paramount importance. Agriculture research is our business and unified agriculture knowledge is our product. Judging from the cutbacks that occurred during the 80's our investors were not convinced that we could produce a viable product. If the 90's continues along the same trend, the agricultural research business will be damn near bankrupt by the year 2000.

More specifically in agronomy, if a another decade goes by without a substantial push towards an integrated approach in both research and production, we will not be a competitive player in the 21st century. If we don't establish long term bench mark sites in the next few years, we will not have cropping systems that can operate profitably within the constraints placed on agriculture by a society increasingly concerned with sustainability and environmental cleanliness.

Dan Heaney

END OF AN ERA

After 34 years, Adolph W. Goettel, the founding father of the Soils Branch, has decided to pursue other interests. Adolph retired from Alberta Agriculture on March 28, but not without fanfare. Some 200 plus family, friends, and co-workers got together on the evening of March 21 to send the big guy off.

While the after dinner festivities were not a roast, Adolph did get gently sauteed by quite a number of his old friends. Among his many trophies from the evening were the Golden Shovel and Chief Clod Awards. Adolph took it in stride as always and even managed to get some back when finally allowed the mike.

Adolph's contribution will be greatly missed by friends and co-workers within the branch and the department. We all wish him a low handicap and the best of luck in future endeavours.

SOILutions is published quarterly by Soils Branch, Alberta Agriculture. Your comments on current contents, ideas and contributions for future articles are welcome. For further information phone, fax, or write *Dan Heaney*, Soil and Animal Nutrition Laboratory, 905 O.S. Longman Bldg., 6909-116 st, Edmonton, Alberta, T6H 4P2, Phone (403)427-6361, Fax (403) 427-1439 **OR** *Elston Solberg*, Soils Branch, J.G. O'Donoghue Bldg., 7000-113 st, Edmonton, Alberta, T6H 5T6. Phone (403) 427-2530, Fax